PCT/AU99/00836

09/806557

REC'D 30 NOV 1999

WIPO PCT

Patent Office
Canberra

I, KAY WARD, TEAM LEADER EXAMINATION SUPPORT AND SALES hereby certify that annexed is a true copy of the Provisional specification in connection with Application No. PP 6242 for a patent by ALCOS TECHNOLOGIES PTY LTD filed on 30 September 1998.

COMMONWEALTH OF AUSTRALIA
AUSTRALIA
PATENT OFFICE

WITNESS my hand this
Twenty-third day of November 1999

K. Ward

KAY WARD
TEAM LEADER EXAMINATION
SUPPORT AND SALES

PRIORITY DOCUMENT
SUBMITTED OR TRANSMITTED IN
COMPLIANCE WITH RULE 17.1(a) OR (b)

AUSTRALIA

Patents Act 1990

PROVISIONAL SPECIFICATION

Applicant:

ALCOS TECHNOLOGIES PTY LTD

A.C.N. 084 307 666

Invention Title:

CYCLONIC EVAPORATOR

The invention is described in the following statement:

CYCLONIC EVAPORATOR

The present invention relates generally to a method and apparatus for separating two or more components of a feed material, particularly a waste stream from an industrial or chemical process containing two or more components from which it is desired to recover or recycle one or other of the components. More particularly, the present invention relates to a method and apparatus for separating or for facilitating separation of two or more liquid components where the liquids have differing properties, such as for example different specific gravities and/or different boiling points. Even more particularly, the present invention relates to a cyclonic evaporator and to a method of using a cyclonic evaporator to separate liquid components from each other and to recover and/or recycle one or more of the liquid components, in which the cyclonic evaporator is provided with a hydrocyclone stage and an evaporator stage. The present invention finds particular application as an improvement to evaporators for separating liquid components from each other in which the improvement is providing a hydrocyclone stage before the evaporator stage in order to achieve more efficient distribution of the waste material to the evaporator, thereby effecting more efficient operation of the evaporator to separate the more volatile component or components of the waste material from the remaining material.

Although the present invention will now be described with particular reference to one embodiment of a cyclonic evaporator for use in separating, in one example, alcohol from aqueous waste material, and in another example water from milk solids, it is to be noted that the scope of the present invention is not restricted to the described embodiments, but rather the scope of the present invention is more extensive so as to include other arrangements of the hydrocyclonic evaporator and its use in other applications and processes, particularly for treating different materials.

Existing evaporators suffer from one or more disadvantages. One such disadvantage relates to the difficulties in separating liquids of different specific gravities or liquids of different volatilities. This is particularly so where evaporators are used to separate volatile materials such as alcohols from aqueous waste materials or water from milk solids.

One reason for the existing difficulties of evaporators relates to the uneven distribution of incoming feed material to the evaporator tubes. In many installations, there is a distribution plate located in the inlet chamber of the evaporator to deflect incoming feed to individual tubes. However, this plate acts as a barrier to the flow of the incoming feed material and causes uneven distribution to individual tubes, particularly where the evaporator is being fed under the influence of gravity only. The deflection and distribution of the incoming feed to individual tubes is achieved by the presence of a number of apertures arranged in a spaced apart array in which each

aperture directs material to an individual tube. As the apertures in the plate are small in size they often become blocked with residues of material from the feed stream, particularly milk solids and the like. Blocking of the apertures further exacerbates the problem of uneven distribution.

Another problem with existing evaporator tubes relates to the build-up of material on the inner wall of the tubes, particularly towards about the top third of the tubes due to incomplete vaporisation of one or more of the components in the feed stream. This is particularly relevant when milk solids or similar materials are present in the feed stream being treated since the milk solids, being essentially oily or fatty in nature, are only partially vaporised, and accordingly form a sticky residue which is deposited on the upper end of the inner wall of the tube. The sticky residue attracts other residual material which in turn adds to the build-up on the walls of the tubes. The deposit of residue reduces heat transference through the wall of the tube which in turn reduces the efficiency of the evaporator.

It is an aim of the present invention to provide a method and apparatus which allows the feed material having two or more components to be separated into the components prior to or simultaneously with evaporation of one or more of the components, so that in combination with the evaporator the components are more effectively separated from each other.

According to a first aspect of the present invention there is provided an apparatus for separating two or more

components of a material prior to or simultaneously with at least partially vaporising one of the components, said apparatus comprising at least one inlet for admitting the feed material containing the two or more components, a device for inducing a first movement to the feed material whereby the two components are partially separated from each other and at least one outlet for discharging the separated components, wherein at least one of the materials is at least partially vaporised prior to being discharged from the outlet.

According to another aspect of the present invention there is provided a method of separating one component from another component of a feed material using a cyclone evaporator comprising admitting the feed material to a part of the apparatus to impart a first movement to the feed material to enhance the chance of one of the components being vaporised, vaporising at least a part of the one component, separating the one component from the other component by the one component having a tendency to remain as a vapour in the apparatus whereas the other component has a tendency or propensity to be condensable to a liquid in the apparatus, and discharging the one and the other component from the apparatus, whereby the separation is substantially maintained.

Typically, the feed material is an aqueous based waste material or an organic solvent based waste material. More typically, the feed material is an alcohol containing aqueous waste material in which the alcohol is typically methanol, ethanol, propanol, or the like.

More typically, the waste material is a fruit juice syrup containing water residues in which it is required to separate the water from the fruit juice concentrate. More typically, the waste material is a mixture of organic materials, such as solvents, and other flammable material. Even more typically, the waste material is a water and milk solids mixture resulting from the diary industry and processes used therein.

Typically, the material being fed to the inlet of the present invention may be at any temperature to enhance separation of the two components.

Typically, at least part of one of the components of the waste material undergoes flash vaporisation on emerging from the motion imparting means of the apparatus. More typically, it is the more volatile of the two materials. Even more typically, the evaporation of the first component is continued in the evaporator. Even more typically, at least one of the components is subjected to the Ranque-Hilsch vortex tube effect, including the temperature exchanges that are produced by this effect.

Typically, the motion imparting means is a hydrocyclone, more typically a hydrocyclone head unit or body unit. Even more typically, the hydrocyclone is a single or multiple hydrocyclone having one, two, three, four or more conduits in the head or body of the hydrocyclone. More typically, the hydrocyclone is a tangential flow hydrocyclone. Preferably, the motion imparting means is an in-line swirl generator. More preferably, the velocity of the components of the waste material is increased by passage through the

hydrocyclone.

Typically, the waste material fed to the in-line swirl generator is under pressure. More typically, the evaporator chamber is under vacuum so that when one or more components emerge from the high pressure zone of the in-line swirl generator to the evaporator tube, it or they undergo flash vaporisation which in turn further increases the velocity of the component or components.

The present invention will now be described by way of example with reference to the accompanying drawings in which:

Figure 1 is a vertical cross-sectional view of one form of the cyclonic evaporator of the present invention,

Figure 2 is a vertical cross-section of a further embodiment of the cyclonic evaporator of the present invention,

Figure 3 is a vertical cross-section of a still further embodiment of the cyclonic evaporator of the present invention,

Figure 4 is a flow chart showing use of the cyclonic evaporator of the present invention *in situ* in one industrial process.

In Figure 1 there is shown one form of the cyclonic evaporator of the present invention, generally denoted as 2. Evaporator 2 comprises an upper portion in the form of a cylindrical cyclone housing 4 having a chamber 6 formed inside the housing. An inlet 8 is located in the side wall of housing 4 for admitting feed material 10 into chamber 6.

Typically, feed material 10 comprises two or more components such as liquids having different specific gravities and/or different volatilities, particularly an aqueous based waste water stream containing contaminants such as alcohols or other volatile components, a milk solids-containing aqueous material, or the like.

A motion imparting device, such as for example an in-line swirl generator (ISG) 14 or similar device, is located within chamber 6. ISG 14 is provided with a top surface 15 in which is located a pair of spaced apart inlet ports 16 for receiving feed material 10 after it has entered chamber 6. Two substantially arcuate conduits 17 are provided within the body of ISG 14 and extend from the inlet ports 16 to outlet ports 18 located in the lower surface of ISG 14. The outlet ports 18 are provided in the lower surface of the ISG 14 so that the inlet feed material is admitted to the ISG in a direction substantially parallel to the longitudinal axis of the evaporator but exits tangentially from the lower surface of the ISG in a rotating or swirling motion as shown by arrows A and B in Figure 1 which denote the flows of generally the two components. However, it is to be noted that any suitable motion imparting device may be used to impart a swirling, rotating, spiralling, helical flow or the like to the feed material. It is to be noted that any suitable apparatus or device for inducing a swirling motion or the like can be used in the method and apparatus of the present invention. Further, it is to be noted that any number of materials may be present in the incoming waste feed and any number of different components can be separated.

An evaporator tube 20 is sealingly connected to the lower surface in use of ISG 14 so that as the partially separated components of the feed stream emerge from ISG 14, they immediately enter evaporator tube 20. In one example, the lower surface of the ISG is provided with a skirt 22 or similar for receiving the upper edge in use of the evaporator tube 20. A cooling jacket 26 is arranged circumferentially around the exterior of the wall 24 of the evaporator tube 20. The jacket 26 is provided with an inlet 28 for admitting coolant or other material 32, typically cold water, and an outlet 30 for discharging the coolant or other material after having heat developed within the evaporator tube transferred thereto or heat supplied to the evaporator tube 20. It is to be noted that in some embodiments material 32 may be used to heat the contents of evaporator tube 20, rather than cooling it.

Chamber 34 is provided at the bottom of evaporator tube 20 for receiving liquid which is condensed in evaporator tube 20. An outlet 36 for discharging condensed vapour or liquid and/or uncondensed vapour is provided at the bottom of evaporator tube 20 to one side for discharging material 37 from tube 20 as will be described in more detail below.

In operation of this form of the apparatus of the present invention, feed stream 10 comprising two or more components of varying specific gravities or differing volatilities, such as waste water contaminated with alcohol, or an aqueous material containing milk solids or the like, is fed under pressure into housing 4 through inlet 8 to fill chamber 6. It is to be noted that feed stream 10 can be at any desirable or suitable temperature. After entering

housing 4, the liquid stream enters the inlet ports 16 of the ISG 14 and travels through the conduits 17 to emerge from the discharge ports 18 in a swirling or rotary motion as indicated by arrows A and B. The inside of evaporator tube 20 and chamber 34 is maintained under a vacuum set in accordance with the particular requirements of the actual materials present in the in-feed stream 10 and the conditions of separating these materials. Accordingly, as the components of the feed stream 10 exit from the ISG 14 they immediately encounter a negative pressure zone maintained within tube 20 in chamber 34, whereupon the more volatile liquid compounds boil and produce vapour in chamber 34. Thus, the lower boiling point component of the feed material undergoes flash vaporisation due to the decrease in pressure and temperature exchanges in accordance with the Ranque-Hilsch vortex tube effect. A further effect of the decrease in pressure is to accelerate the vapour to a high velocity. Thus, the combined effect of imparting a swirling motion to the feed material to increase its velocity and subjecting it to a large drop in pressure has the effect of accelerating the material to an even higher velocity than is achievable by using the ISG alone. This in turn affects the subsequent motion of the different components. Heavier liquids are thrown outwardly at high speed towards the wall 24 of the chamber 34 to contact the wall of tube 20 as shown generally by arrow A and spiral down this wall in a thin liquid film 38. Vapours and non-condensable gases on the other hand spiral at high velocity towards the centre of tube 20 and down and around the central axis of the tube to form a core 40 of the material flow, as shown generally by arrow B. Thus, by this combined effect the more volatile component is

vaporised and tends to follow a pathway down the centre of tube 20 whereas the less volatile component is not vaporised and flows down the wall of tube 20, thereby effecting separation of the two components to a greater or lesser extent.

The liquid spiralling down the wall 24 of the jacket 20 condenses some of the higher boiling temperature vapours in the inner core 40 of the spiral flow due to heat transference from the vapours to the liquid which allows the lower boiling temperature vapour to remain as vapour while the high velocity spiralling liquid continues down the wall of the chamber together with a reduced quantity of low boiling temperature vapour so that both can exit through the chamber outlet 36 as a combined flow 37.

Alternatively, in another embodiment there is the possibility of allowing hot liquid or gas to enter the jacket 26 in place of coolant 32 where the liquid or gas is at a temperature of 1°C or more in excess of that of the liquid within tube 20 and chamber 34 so that additional vaporisation of the spiralling liquid against the walls of the tube occurs and increases the rotational velocity of the liquid inside tube 20 and increasing the amount of vaporisation of this component which in turn increases the amount of material passing through chamber 34 and exiting this chamber through outlet 36. It is to be noted that both liquid and vapour are discharged simultaneously from outlet 36 in that the liquid tends to collect at the bottom of and along the lower surface of chamber 34 and outlet 36 whereas the vapour ends to collect in the upper region of outlet 36. The vapour and liquid being discharged through

outlet 36 are fed to a further separator to complete separation of the liquid and vapour into two distinct streams as shown more clearly in Figure 4.

The wall 24 of chamber 20 can be from 1 to 20 metres in length. The thin liquid film 38 flowing down the wall 24 of the tube 20 and inside chamber 34 is partially cooled by the coolant 32 circulating in jacket 26.

A modification of the embodiment just described is shown in Figure 2, in which there is a reject nozzle fitted to the housing 4 allowing vapour to escape upwardly into a secondary chamber located at or towards the top of the housing. In this embodiment, similar reference numerals are used to denote corresponding features of the embodiment of Figure 1. In this embodiment, there is a reject nozzle 40 located in the bottom surface of ISG 14 which nozzle is in fluid communication with reject conduit 42 extending internally through ISG 14 about the central axis of ISG 14 to upper chamber 46 located above housing 4. Upper chamber 46 is provided with outlet 48 for discharging vapours 50 from chamber 46. This embodiment is particularly adapted to remove air and other gases from the feed stream, particularly where the feed stream is aerated. Feed material containing air or other gas, such as for example nitrogen, is admitted through inlet 8 to housing 4 whereupon it enters ISG 14. On entering inlet ports 16, the feed material is forced through conduits 17 to emerge through discharge ports 18 in a swirling motion. As chamber 34 is under vacuum, there is a sudden drop in pressure on transiting from ISG 14 to evaporator tube 20. In combination with the swirling motion and drop in

pressure, the air or gas has a tendency to collect in a central core in tube 20, whereas the less volatile liquid material is thrown towards the outside of the tube against walls 24. The more volatile material tends to adopt a flow path intermediate the central core of gas and the outer flow of liquid.

The air or other gas in the flow path of the central core of tube 20 rises in tube 20 to enter reject nozzle 40 and flow through reject conduit 42 to upper chamber 46 and then to outlet 48, whereupon the gas is discharged from the apparatus.

Simultaneously with the air or gas moving upwardly through reject nozzle 40 and conduit 42, the vapour in the intermediate flow path travels towards outlet 36 for discharge through outlet 36 whilst the liquid in the outer flow path adjacent wall 24 spirals down the wall to accumulate at the bottom of chamber 34 for discharge along the lower portion of outlet 36. It is to be noted that the vapour of component one is discharged simultaneously with the liquid of component two through outlet 36.

In Figure 3 there is shown a further embodiment of the present invention in which there are a multiple of individual evaporator tubes 20 located within the one housing. Each evaporator tube 20 is provided with its own ISG 14. The operation of this form of the apparatus of the present invention is similar to the operation of the previously described forms. In this form of the invention, material 10 entering inlet 8 under pressure flows under pressure to each ISG so that the material entering each of

the respective inlet ports of each ISG is at the same pressure which enhances even distribution of material to each individual evaporator tube 20 to achieve more efficient separation of the components. In the embodiment shown in Figure 3, each ISG is provided with a centrally located reject nozzle and reject conduit 42 in fluid communication with upper chamber 46. The arrangement shown in Figure 3 enables feed material to be uniformly and evenly distributed to each evaporation tube 20 which results in more even distribution of the incoming feed material and more efficient separation of the components of the feed material.

The vapours and liquid emerging from the base of tube 20 are collected in chamber 60 for discharge through outlet 62. Upper separation plate 64 maintains individual tubes 20 in spaced apart relationship, whereas lower separation plate 66 maintains the lower end of individual tubes 20 in spaced apart relationship.

Figure 4 is a flow chart showing one example of where the apparatus of the present invention can be used as part of an overall industrial process. In the embodiment shown in Figure 4, the cyclonic evaporator 2 is shown with inlet 8 through which feed 10 is admitted to the cyclonic evaporator. Coolant 32 is admitted to jacket inlet 28 and discharged through outlet 30. Vapour is discharged from cyclonic evaporator through outlet 48 whereupon it passes to line 60 coming from primary separator 62. Primary separator 62 receives vapour and liquid from outlet 36 through line 64 and separates this material into a vapour which is discharged through line 66 to join with line 60

for subsequent processing. Line 68 from separator 62 carries liquid for further processing.

Advantages of the present invention include being able to accurately or at least more evenly distribute liquids from the main feed stream to the evaporation tubes so that more efficient evaporation can take place, particularly when a cylindrical form of the housing is used.

More effective cleaning of the housing is possible since there are no distribution plates, trays or like baffles located in the housing to prevent effective cleaning *in situ*.

The ability to produce very high velocity rotating liquid directly to the evaporator tube and chamber is possible. Flow down the length of the inner wall of the tube or chamber prevents fouling deposits on the inner tube walls and the like.

The provision of the in-line swirl generator allows flash evaporation into tube 20 to take place, followed by immediate partial condensing or condensation of the vapours produced during the flash evaporation. This is possible by allowing cooling fluid or gas to be applied to the chamber walls to effect partial condensation or condensation of the vapours in the evaporation tube.

The apparatus of the present invention provides the ability to allow volatile vapours or non-condensable gases to be removed from the top of the chamber through the reject nozzle. Additionally, the size of the reject nozzle can be

varied which allows adjustment of the amount of volatile vapours or non-condensable gases to be removed from the evaporation chamber through the reject nozzle. Higher boiling temperature vapours can be immediately condensed or partially condensed by allowing cooling fluid or gas to be applied to the chamber walls.

The present invention provides the ability to allow flash evaporation or evaporation and condensing or partial condensing to take place in a single or multiple tube evaporator cylinder by adjusting the length of the cooling chamber along the length of the chamber wall.

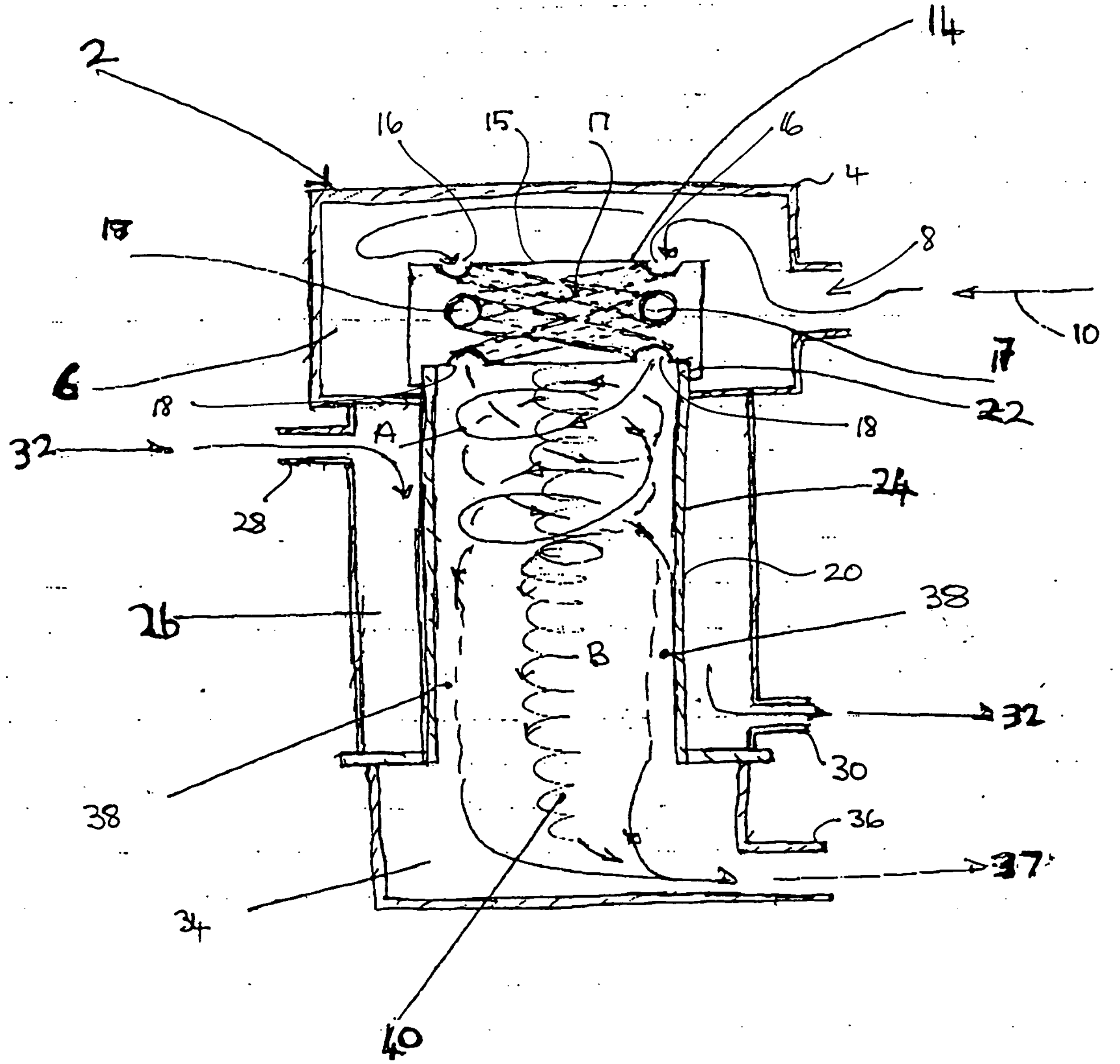
The described arrangement has been advanced by explanation and many modifications may be made without departing from the spirit and scope of the invention which includes every novel feature and novel combination of features hereindisclosed.

Those skilled in the art will appreciate that the invention described herein is susceptible to variations and modifications other than those specifically described. It is understood that the invention includes all such variations and modifications which fall within the spirit and scope.

Dated: 30 September 1998

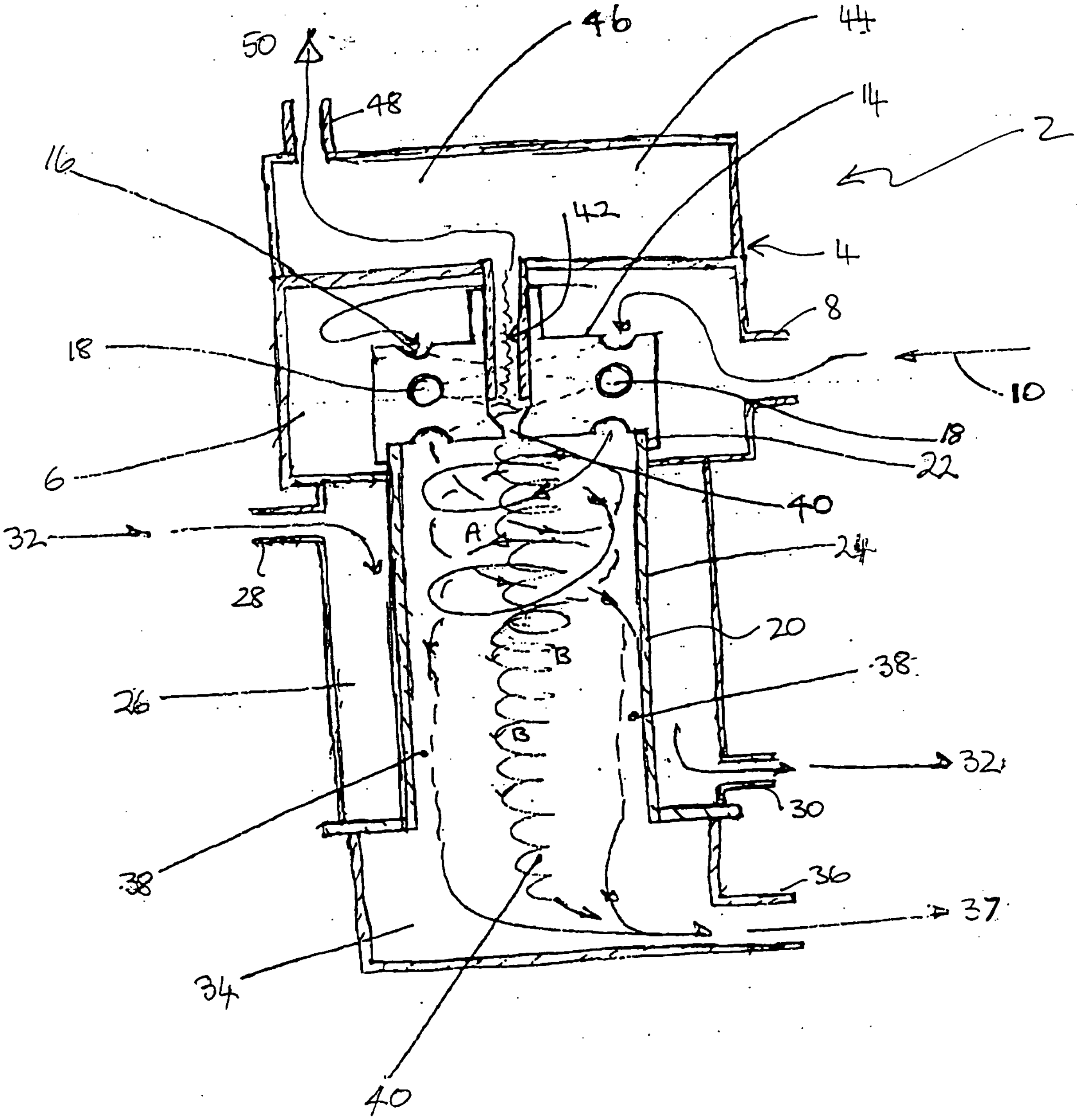
ALCOS TECHNOLOGIES PTY LTD

FIGURE 1



2
14
16
15
17
16
4
8
18
10
6
17
18
22
18
A
32
24
28
20
26
38
B
32
30
38
36
37
34
40

FIGURE 2



50
46
44
48
14
2
16
42
4
8
18
10
18
22
6
40
32
A
24
28
20
B
38
26
B
32
30
38
36
37
34
40

FIGURE 3

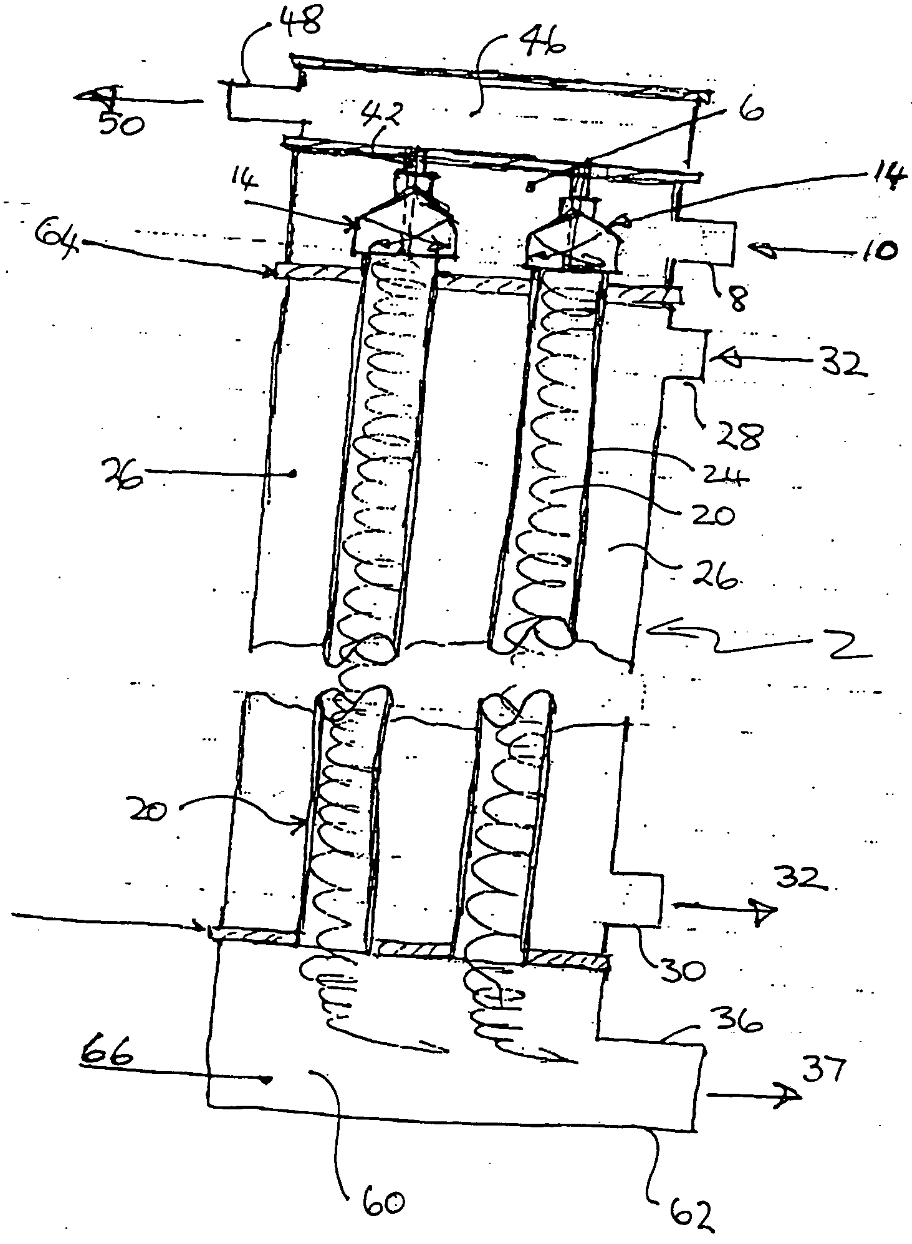


FIGURE 4